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BENEFICIAL EFFECTS OF ALTERNATIVE LIGHTING SCHEDULES ON THE INCIDENCE OF ASCITES AND ON METABOLIC PARAMETERS OF BROILER CHICKENS

M. HASSANZADEH[1*], M. H. BOZORGMEHRI FARD[1], J. BUYSE[2] and E. DECUYPERE[2]

[1]Department of Poultry Diseases, Faculty of Veterinary Medicine, University of Tehran, P.O. Box 14155-6453, Tehran, Iran; [2]Laboratory for Physiology and Immunology of Domestic Animals, K. U. Leuven, Leuven, Belgium

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The beneficial effects of different lighting programmes on the incidence of ascites was investigated in an experiment with 360 three-day-old male broiler chickens. At 3 days of age, chicks were randomly divided over three rooms in a high-altitude farm, 2000 m above sea level. During days 14 to 28 ambient temperature decreased during the night but the minimum temperature did not descend below 15 °C. In the first room the continuous lighting schedule (CL, 23L:1D) was maintained and in the second room an intermittent lighting schedule (IL, 1L:3D), repeated six times daily, was imposed from 3 days of age. In the third room, an increasing photoperiod schedule (IP, 4 to 14 days, 6L:18D; 15 to 21 days, 10L:14D; 22 to 28 days, 14L:10D; 29 to 35 days, 18L:6D; 36 to 42 days, 23L:1D) was provided. Mortality associated with right ventricular failure and ascites was numerically lower in birds reared under the IL and IP schedules compared to birds reared under the CL schedule, which can be attributed to the temporary reduction in relative growth and feed intake in IL and IP birds. It was concluded that the beneficial effect of lighting schedules could be due to a reduced metabolic rate as a consequence of the altered growth trajectory, as also reflected in the lower haematocrit and plasma T_3 levels of IL and IP birds compared to CL birds.

Key words: Ascites, broilers, lighting schedules, altitude, thyroid hormones

During the last decades, several livestock species, particularly meat-type chickens, have been intensively selected for improved growth rate. This has greatly reduced the time to reach the desired market weight. However, increased growth rate has been accompanied by a severe incidence of ascites in the commercial broiler industry throughout the world (Olkowski et al., 1999). The ascites syndrome results in significant economic losses to the poultry industry due to mortality, reduced weight gain and increased condemnation at slaughter. The causes of the syndrome are multifactorial and mainly induced by exogenous

*Corresponding author; E-mail: Mhzadeh@Chamran.ut.ac.ir; Fax: 0098216933222

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and/or endogenous factors. An imbalance between oxygen supply and the oxygen required to sustain rapid growth rates and high food efficiencies could lead to ascites in broiler chickens (Decuypere et al., 2000).

It is common practice to raise broiler chickens in continuous or near continuous illumination and/or is recommended that a short dark period should be included to accustom the birds to darkness and to minimise panic in case of power failure (Buyse et al., 1996). Currently, there is interest in discontinuous lighting patterns such as an increasing photoperiod lighting system (Classen et al., 1991; Blair et al., 1993) and/or intermittent lighting schedules (Buys et al., 1998; Hassanzadeh et al., 2000) for broilers because these alternative lighting programmes could improve broiler performance and reduce the occurrence of metabolic disorders such as sudden death syndrome and ascites. The purpose of the present work was to design a comparative study on the beneficial effects of different lighting programmes on the incidence of ascites and on metabolic parameters of broiler chickens under local conditions of high altitude in Iran.

Materials and methods

A total of 360 day-old male broiler chickens of a commercial strain (Ross) were reared under a nearly continuous lighting schedule 23 L: 1D (CL) until 3 days of age. From day 4 on, they were randomly divided over three light-proof, equal-sized rooms (4.5 × 4 m), each containing three floor pens (40 chicks per pen) and housed in a high-altitude farm 2000 m above sea level in central Iran. In the first room the CL schedule was maintained whereas in the second room an intermittent lighting schedule (IL) consisting of 1L:3D cycles, repeated six times daily, was imposed from 3 days of age. For the chickens of third room, an increasing photoperiod schedule (IP) was provided: 4 to 14 days, 6L:18D; 15 to 21 days, 10L:14D; 22 to 28 days, 14L:10D; 29 to 35 days, 18L:6D; 36 to 42 days, 23L:1D according to Classen et al. (1991). Temperature was regulated as previously described (Hassanzadeh et al., 2002). Briefly, it was set initially at 33 °C and gradually reduced with 1 °C/2 days until 22 °C was reached. During the period from 14 to 28 days the electrical heating system was turned off during the night while the minimum environmental temperature did not descend below 15 °C. A commercial broiler crumble diet containing 3100 Kcal/kg ME and 210 g/kg CP and water were provided for*ad libitum* consumption throughout the experiment. During the study, except for the lighting schedules, the rest of environmental conditions remained similar for all groups.

From day 3 onwards, weekly body weights and feed intake were measured per pen. From 10 randomly selected birds per group, venous blood samples were taken weekly from day 7 on. Each week, blood samples were obtained during the last part of the light period. Blood was collected in capillaries for haematocrit and in heparinised tubes on ice for the separation of plasma. Haematocrit was measured immediately while blood samples were centrifuged for 10 min at 1500 × *g*. The separated plasma samples were stored at –20 °C until further analysis. Plasma was analysed for both thyroid hormones, T_3 and T_4 as described earlier (Decuypere et al., 1994). At the end of the experiment, 40 chickens from each group were slaughtered. These birds and also the broilers that died during the experimental period were examined for lesions of heart failure syndrome and ascites. The heart was removed and the atria, major vessels and fat were trimmed off. The right ventricle/total ventricle ratio (RV/TV) was measured as described previously by Julian (1987). Statistical analysis was performed using the 'General linear model procedure' (SAS, 1986). If a significant overall effect ($p < 0.05$) was found, treatment means were compared by using the Scheffe test. Because the lighting treatments were only replicated within a room, it was not possible to test for room effects, and the error term used for tests was measured within-rooms. Consequently, caution is required when comparing treatment means because they were not in the same room.

Results

The incidence of right ventricular hypertrophy (RVH) and ascites increased with age but differently according to the lighting schedule (Table 1).

Table 1

Age-related mortality due to right ventricular failure (RVF) and ascites, and the number of surviving birds suffering from right ventricular hypertrophy (RVH) and ascites in commercial broiler chickens reared under different lighting schedules

Lighting groups	RVF and ascites mortality in age (day)							RVH and ascites
	7	14	21	28	35	42	*Total*	
CL	0	1	0	2	12	3	*18*	8/40
IL	0	0	0	3	2	1	*6*	3/40
IP	0	0	0	1	1	5	*7*	2/40
Total	*0*	*1*	*0*	*6*	*15*	*9*	*31*	*13/120*

CL = Continuous lighting (23L:1D); IL = Intermittent lighting (1L:3D cycles); IP = Increasing photoperiod (4 to 14 days, 6L:18D; 15 to 21 days, 10L:14D; 22 to 28 days, 14L:10D; 29 to 35 days, 18L:6D; 36 to 42 days, 23L:1D)

During the experiment 44 (12.2%) of the 360 birds died. Of these birds 31 (8.6%) died of right ventricular failure (RVF) and ascites. The first cases of ascites occurred from day 14 in chickens reared under the CL schedule but the rate increased between days 28 and 42. During the 42 days of the growing period, 18 birds that had been reared under the CL programme died of RVF and ascites while only 6 birds reared under interrupted lighting schedule and/or 7 birds reared under increasing photoperiod schedule died as a result of RVF and ascites. The other 13 dead birds had no lesions of ascites and died of other causes including neonatal infection, arthritis and sudden death syndrome. At the end of the experiment, the number of birds with RVH and ascites of surviving chickens that were selected randomly and slaughtered was numerically higher in the birds that had been reared under the CL (8/40) schedule compared with the IL (3/40) and/or IP (2/40) schedule.

Table 2

Relative growth, feed intake and feed conversion ratio in commercial broiler chickens reared under different lighting schedules. Values are means ± SEM (n = 3 pens per lighting schedule)

Parameters/age	Different lighting schedules			P value
	CL	IL	IP	
Relative growth rate (%)				
Days 3–7	116 ± 2^{a}	95 ± 3^{b}	85 ± 4^{b}	P < 0.005
Days 7–14	191 ± 2	198 ± 6	188 ± 3	NS
Days 14–21	85 ± 3	91 ± 4	95 ± 6	NS
Days 21–28	60 ± 2	61 ± 4	65 ± 2	NS
Days 28–42	56 ± 3	56 ± 2	60 ± 2	NS
Feed intake (g/chicken)				
Days 3–7	124 ± 8	115 ± 8	95 ± 9	NS
Days 7–14	412 ± 10^{a}	372 ± 25^{ab}	305 ± 34^{b}	P < 0.05
Days 14–21	743 ± 19^{a}	674 ± 12^{ab}	648 ± 37^{b}	P < 0.05
Days 21–28	1105 ± 27	1074 ± 10	1065 ± 27	NS
Days 28–42	2218 ± 21	2248 ± 67	2275 ± 47	NS
Days 3–42	4601 ± 41^{a}	4473 ± 37^{ab}	4388 ± 42^{b}	P < 0.05
Feed conversion ratio (g/g)				
Days 3–7	1.49 ± 0.05	1.71 ± 0.17	1.54 ± 0.10	NS
Days 7–14	1.50 ± 0.05	1.31 ± 0.12	1.21 ± 0.03	NS
Days 14–21	1.98 ± 0.08	1.79 ± 0.09	1.77 ± 0.06	NS
Days 21–28	2.18 ± 0.05	2.19 ± 0.03	2.13 ± 0.06	NS
Days 28–42	2.93 ± 0.12	3.12 ± 0.13	3.10 ± 0.18	NS
Days 3–42	2.28 ± 0.02	2.29 ± 0.03	2.28 ± 0.03	NS

CL = Continuous lighting (23L:1D); IL = Intermittent lighting (1L:3D cycles); IP = Increasing photoperiod (4 to 14 days, 6L:18D; 15 to 21 days, 10L:14D; 22 to 28 days, 14L:10D; 29 to 35 days, 18L:6D; 36 to 42 days, 23L:1D); NS = not significant; Within rows, means with no common superscripts are significantly different (P < 0.05)

Mean relative growth, feed intake and feed conversion ratio (FCR) for the different lighting treatment and the result of statistical analysis are summarised in Table 2. The change from CL to IL and IP significantly reduced the growth rate of birds between 3 and 7 days of age. From day 7 onwards, there was no effect of lighting schedule on the relative growth of birds. At the end of the study, there was no significant difference in final body weight at slaughter age between birds reared under CL (2095 ± 25 g/bird), IL (2021 ± 28 g/bird) and IP (1998 ± 10 g/bird) lighting programmes. Feed intake was significantly higher in birds reared under the CL schedule up to 21 days of age and also over the entire period. The lighting programme had no significant effect on feed conversion ratio at any age.

Table 3

Mean haematocrit values %, plasma T_3 and T_4 levels (ng/ml) in commercial broiler chickens reared under different lighting schedules. Values are means ± SEM (n = 10)

Parameters/age	Different lighting schedules			P value
	CL	IL	IP	
Haematocrit values (%)				
Day 14	39 ± 0.3^a	36 ± 0.5^b	37 ± 0.4^b	$P < 0.01$
Day 21	37 ± 0.6^a	36 ± 0.7^b	35 ± 0.3^b	$P < 0.05$
Day 28	41 ± 0.5^a	40 ± 0.6^a	36 ± 0.6^b	$P < 0.0001$
Day 35	42 ± 0.6^a	39 ± 0.7^a	38 ± 0.7^b	$P < 0.01$
Plasma T_3 levels (ng/ml)				
Day 7	6.1 ± 0.2^a	4.6 ± 0.3^b	4.7 ± 0.4^b	$P < 0.05$
Day 14	6.7 ± 0.8	5.5 ± 0.6	5.8 ± 0.4	NS
Day 21	5.3 ± 0.4^a	4.8 ± 0.5^{ab}	3.7 ± 0.2^b	$P < 0.05$
Day 28	4.8 ± 0.4	4.7 ± 0.3	4.7 ± 0.5	NS
Day 35	3.3 ± 0.6	2.4 ± 0.5	2.2 ± 0.2	NS
Day 42	2.4 ± 0.4	1.9 ± 0.3	2.5 ± 0.2	NS
Plasma T_4 levels (ng/ml)				
Day 7	1.7 ± 0.3^b	2.5 ± 0.2^a	2.2 ± 0.2^{ab}	$P < 0.05$
Day 14	4.5 ± 0.4	3.5 ± 0.3	3.4 ± 0.5	NS
Day 21	2.9 ± 0.5	2.8 ± 0.4	2.7 ± 0.3	NS
Day 28	3.6 ± 0.3	4.0 ± 0.5	4.3 ± 0.7	NS
Day 35	3.0 ± 0.3^b	5.6 ± 0.7^a	6.4 ± 0.6^a	$P < 0.0001$
Day 42	4.9 ± 0.7^b	6.3 ± 0.7^b	11.0 ± 2.0^a	$P < 0.005$

CL = Continuous lighting (23L:1D); IL = Intermittent lighting (1L:3D cycles); IP = Increasing photoperiod (4 to 14 days, 6L:18D; 15 to 21 days, 10L:14D; 22 to 28 days, 14L:10D; 29 to 35 days, 18L:6D; 36 to 42 days, 23L:1D); NS = not significant. Within rows, means with no common superscripts are significantly different (P < 0.05)

The influence of lighting programme on mean haematocrit values was significant during the experimental period (Table 3). Broiler chickens reared under IL and IP schedules showed significantly lower haematocrit values compared to those of birds reared under the CL schedule at 14 and 21 days of age. At 28 and 35 days of age only the haematocrit values of IP birds were significantly decreased compared to both of CL and IL birds. During the first 21 days, mean plasma T_3 levels for CL birds were generally higher than for IL and IP, but the difference was only significant at 7 and 21 days. Plasma, T_4 levels were variable, but when significant, CL chickens had the lowest values.

Discussion

There is an agreement that the long-term solution for ascites syndrome is breeding for resistance to ascites, a trait that can be selected for without necessarily reducing the growth potential of broiler lines (Hernandez, 1987), but for a short-term solution, much research has focused on the possible beneficial effects of different management strategies in reducing the incidence of ascites. As described earlier (Blair et al., 1993; Hassanzadeh et al., 2000), in the present study imposing of intermittent lighting programmes or increasing photoperiod was followed by an initial growth reduction. This reduction was, however, not followed by a period of compensatory growth in our study, but the overall results suggest that these alternative lighting programmes are beneficial in reducing of the incidence of RVH and ascites with at least no significant reduction in body weight at market age. This finding on mortality could be explained by different mechanisms. It has been shown that with IL, heat production and oxygen consumption are significantly lower during the dark period of each lighting L:D cycle (Buyse et al., 1996). Because a suboptimal supply of oxygen and/or higher demands are known to be the primary cause of development of ascites, a lower heat production and hence oxygen needs could reduce the incidence of ascites. The lower heat production could also explain the decreased ascites incidence in the IP treatment, as suggested by Blair et al. (1993). The incidence of ascites is much higher in fast-growing broiler lines than in slower-growing ones (Julian, 1993; Decuypere et al., 1994). The lesions of ascites are the last stage in a cascade of events leading to ascites and the predisposition for the development of the syndrome already occurs during the first weeks of the growing period (Coleman and Coleman, 1991). It is exactly during this initial period that the growth rate, and hence the oxygen requirements, of IL and IP chickens are reduced which alleviates the metabolic load and, therefore, the development of ascites (Buys et al., 1998; Hassanzadeh et al., 2000).

The reduction in mortality due to ascites also coincided with lower values of indicators for metabolic rate, e.g. plasma T_3 levels and haematocrit, in birds under IL and IP light schedules, strengthening the view that a lower metabolic rate had a beneficial effect on the incidence of ascites. The lower haematocrit values confirm the earlier finding of Hassanzadeh et al. (2000) and may decrease blood viscosity in narrow capillaries of the lungs and, as a consequence, could reduce pulmonary hypertension and ascites (Julian, 1993). The impact of the alternative lighting programmes on plasma thyroid hormone levels and their interrelationship change according to the age of the birds. As blood samples from IL and IP chickens were obtained during the last stages of the photoperiod, and hence after initiation of feed intake, their generally higher levels of T_4 probably result from the altered feed intake pattern, as was reported by Kühn et al. (1996) and Hassanzadeh et al. (2000).

Although the values for relative growth rate of IL and IP chickens during the second period were on average higher compared to those of CL chickens, these was no statistical evidence for compensatory growth. The lack of compensatory growth is in contrast with some reports (Classen and Riddell, 1989; Blair et al., 1993). The reason for this discrepancy is yet speculative but might be related to the clear differences in rearing conditions such as altitude etc. between these studies. In additional, it is not excluded that if the trial was continued after 42 days, IL and IP chickens might have displayed full catch-up growth. However, IL and IP lighting schedules tended to reduce final body weight at the market age compared to CL broiler chickens. There was no difference in feed efficiency among lighting treatments, confirming the earlier finding of Classen et al. (1991) and Hassanzadeh et al. (2000). In the present experiment the cumulative feed intakes were significantly different at day 42 but there were no significant differences in FCR. Therefore, it is suggested that the absence of statistically significant differences in FCR is due to the numerical though not significant differences in body weight gain between birds reared under CL (2023 ± 26 g/bird), IL (1950 ± 27 g/bird) and IP (1917 ± 14 g/bird). The incidence of RVH in surviving birds at the end of the experiment and mortality attributed to ascites were numerically similar in birds reared under IL and IP schedules. In both lighting treatments, early reduction of growth rate associated with a change in thyroid hormones at the same time has been suggested as factors contributing to the reduction in RVH and ascites incidence. The difference in growth rate between the IL and IP schedules was only significant at 7 days and from day 7 onwards birds in both groups grew at the same rate.

Based on these data it can be concluded that both intermittent lighting and increasing lighting schedules were superior to a long-photoperiod regime in terms of flock health and can be recommended for commercial broiler production. However, continued research concerning the effects of these lighting treatments on the metabolic disorders, growth performances and on behavioural traits and welfare of the broiler chickens in commercial flocks instead of small-scale experimental designs, could further elucidate the beneficial of effects of these alternative lighting regimes, especially in ascites-inducing circumstances.

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